BIOLOGY AND SEASONAL HISTORY OF *CALLIGRAPHA SPIRAEAE* (SAY) (COLEOPTERA: CHRYSOMELIDAE), WITH DESCRIPTIONS OF THE IMMATURE STAGES

A. G. Wheeler, Jr. and E. Richard Hoebeke

Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, PA 17120 and Department of Entomology, Cornell University, Ithaca, NY 14853, respectively

Abstract

Details of seasonal history and habits, relative abundance and damage, and duration of the immature stages of *Calligrapha spiraeae*, a chrysomelid feeding on ninebark, *Physocarpus opulifolius* (L.) Maxim., are presented and discussed. The beetle's seasonal cycle is bivoltine in southcentral Pennsylvania, with peak adult emergence occurring during the last week of June to early July, and mid- to late August. Eggs are deposited usually in irregular clusters or occasionally singly on the lower leaf surfaces of the food plant. All 4 larval instars feed externally on the leaf surfaces. Larval development is completed in an average of 18.9 days in the laboratory. After feeding several days, the fourth-instar larva drops to the soil and pupates beneath the surface. The pteromalid wasp *Erixestus winnemana* Crawford parasitizes the egg clusters of the beetle. The egg, last instar larva, and pupa are described and illustrated. An existing key to *Calligrapha* larvae is revised to include *spiraeae*.

Leaf beetles of the chrysomeline genus *Calligrapha* are readily recognized by their broadly oval, convex form and dark, sometimes metallic, elytral markings on a paler, often creamy-white background. This New World genus contains 73 species, with 36 occurring in America north of Mexico (Wilcox 1972 and 1975).

The importance of using host plant data to delimit species in the genus has long been appreciated. Walsh (1864) observed host preferences of several species of *Calligrapha*; however, he considered the slightly different morphological forms of *C. scalaris* (LeConte) occurring on different host plants to represent "phytophagic varieties." Knab (1909) described two additional species that have subsequently been synonymized with *scalaris*. It took Brown's (1945) study to reveal the large number of siblings present in the *scalaris* complex. He described 8 new species in the *scalaris* group and corrected most of the erroneous host plant associations recorded in the literature.

Many species of *Calligrapha* feed on plants of little economic importance, and populations of those associated with shade trees and ornamental plants only occasionally reach damaging levels. Biological data therefore are lacking for all but a few members of the genus. In Canada, Gibson (1904) and Ainslie (1925) discussed the habits of *C. pnirsa* (Stal) on basswood, *Tilia americana* L. Whitehead (1920) and Daviault (1941) in Canada and Tanner (1958) in Utah have studied *C. multipunctata* (Say) on various willows, *Salix* spp. Hegner (1908, 1910) added additional information based on populations of *C. multipunctata* from the upper Midwest. In Kansas,

Dean (1946) reported on the seasonal history of *C. scalaris* on American elm, *Ulmus americana* L. Whitehead's (1919) study in Nova Scotia of a species listed as *C. scalaris* on black alder, *Alnus glutinosa* (L.) Gaertn., should refer to *C. confluens* Schaeffer. Hicks (1949) gave notes on damage to ornamental dogwood, *Cornus* sp., by *C. philadelphica* (L.) in Ontario.

Recently Mullins (1976) elucidated the habits of *C. spiraeae* (Say), a species he reported from Quebec[1] south to North Carolina and west to Michigan and Missouri. Since *C. spiraeae* apparently has not been reported from New York, we list the following record: Aurora, Cayuga Co., 11 June 1978, 1 adult on *Physocarpus opulifolius,* L. L. Pechuman, collector. Ninebark was known as the food plant when Say (1826) described this species; the name *spiraeae* was given because at the time *Physocarpus* was included in the genus *Spiraea.* The biology remained unknown until Mullins studied its seasonal history in Virginia and provided information on developmental times and oviposition habits.

In late June 1977 we were alerted to an outbreak of *C. spiraeae* in an ornamental planting of ninebark in southcentral Pennsylvania. We initiated a study of this population when preliminary observations indicated that the seasonal history differed from that reported for the Virginia population. In this paper we discuss seasonal history based on observations (by A. G. W.) of *C. spiraeae* on ornamental and native ninebark and give notes on developmental times of the larval and pupal stages. The egg, last instar larva, and pupa are described and illustrated (by E. R. H.), and Brown's (1945) key to mature larvae is revised to include *C. spiraeae.*

Methods

Seasonal history of *C. spiraeae* was studied in an ornamental planting of ninebark (70m long X 2m wide) in a rest area along Interstate Highway 81 in Dauphin Co., Pennsylvania, just south of exit 28. Observations were made at weekly or 10-day intervals from late June to late August, 1977, and from early July to September, 1978. On 3 occasions relative abundance of the adults was estimated by beating 15 terminals of the plant over a tray (30 X 24cm). Observations were also made at regular intervals during the period of June to August, 1977, and April to September, 1978, on native ninebark growing along a stream approximately 15 km from the main study site.

Developmental times were based on laboratory rearings maintained at ca. 20-22° C using a natural photoperiod. Larvae were placed with ninebark leaves in small plastic Petri dishes. Foliage was renewed every 2 to 3 days.

Biology

Seasonal history. The generalized field history (Fig. 1) is based mainly on a population from native ninebark observed from April to October 1978. It is supplemented by collections from the same planting during August to September, 1977, and from an ornamental planting during late June to August, 1977, and early July to September, 1978.

Adults leave their overwintering sites soon after the first flush of leaves on ninebark, mid-April in 1978. A few small clusters of eggs were found

[1]The only Canadian record for *C. spiraeae* is: Wiarton, Ontario, 19 June 1956, W. J. Brown, collector. The Quebec record remains in doubt (pers. comm., E. C. Becker).

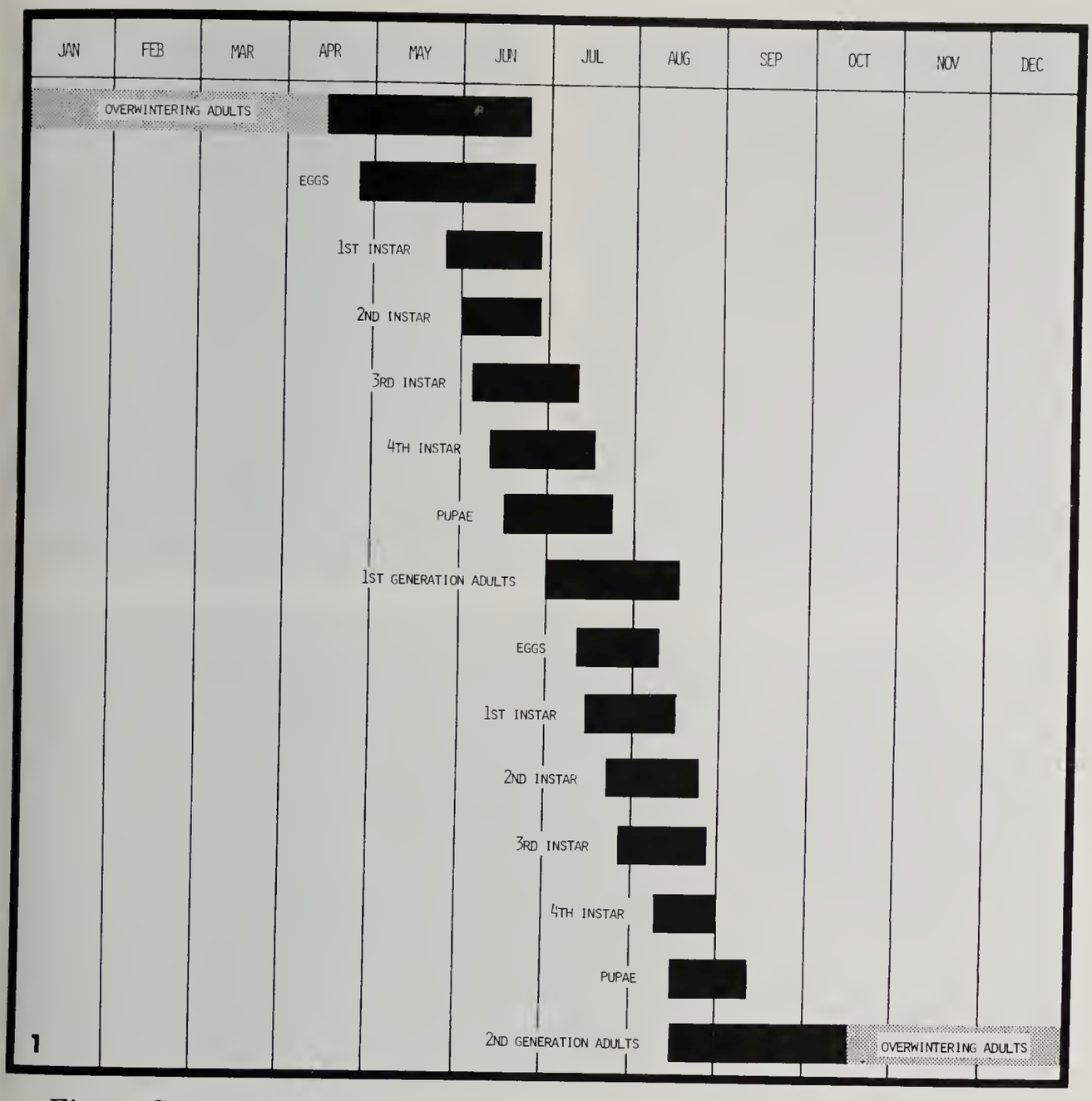
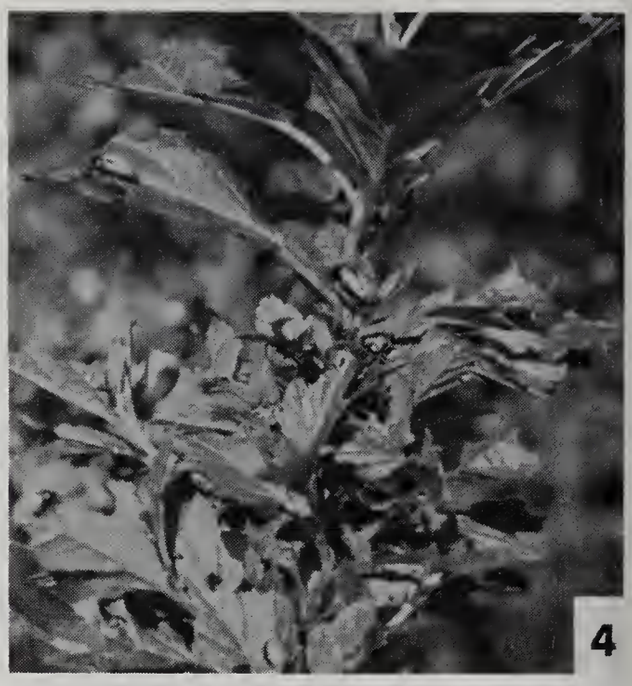


Fig. 1. Seasonal history of *Calligrapha spiraeae* on *Physocarpus opulifolius* in Pennsylvania. (Note: stippling indicates period when adults are overwintering in duff and black when they are on ninebark plants.)

during late April, but a return to cooler weather delayed further oviposition until the second week of May. The majority of eggs was laid during May 10 to 20. Nearly all were deposited on the lower leaf surfaces of their host plant, usually irregularly arranged (Fig. 2), but sometimes placed in double rows. Rarely a single egg was laid, and only occasionally were eggs deposited on the upper leaf surface or on petioles of the host plant. The average number of eggs in a cluster was 5.9 (range 2-13, n = 21).

Eggs in one of the clusters found in late April began to hatch on May 20, but early instar larvae did not become numerous until the first week of June and unhatched eggs were observed until ca. June 20. First-instar larvae fed by making nearly circular holes through a leaf (Fig. 3).

Third- and fourth-instar larvae were collected as early as June 3 and were present on the foliage until mid-July. These older larvae often fed near the edge of a leaf, giving it a ragged appearance. Fourth-instar larvae fed for several days before dropping to the ground to pupate just beneath



Figs. 2-5. Life stages of *Calligrapha spiraeae* and damage to host plant, *Physocarpus opulifolius*. 2) Egg cluster deposited on lower leaf surface of food plant. 3) Feeding damage caused by first-instar larvae. 4) Adults feeding on foliage of host plant. 5) Ornamental planting of ninebark totally defoliated by adults and larvae.

the soil surface. Adults of the first generation began to emerge in late June and continued to emerge for several weeks. The number of overwintered adults declined sharply during the third week of June, possibly indicating that most of the overwintering adults had died.

Recently emerged adults began to mate in early July. In both 1977 and 1978 *C. spiraeae* produced only a small second generation on native ninebark. Eggs were present from the second week in July to early August, larvae from mid-July to late August. Adults of the second generation remained on ninebark until the first heavy frosts (mid-October).

Relative abundance and damage. In the ornamental planting of ninebark, the size of the large first generation of *C. spiraeae* was estimated near the end of adult emergence when only a few fourth-instar larvae remained on the plants and when only a few pupae and teneral adults were found in

duff samples taken from beneath the planting. On June 29 the number of adults averaged 25.5 on the terminal 30 cm of 15 ninebark branches (range 3-64). The population had declined when similar counts were made in mid-July and early August. Adults averaged 18.3/terminal on July 15 (range 5-43) and only 1.3/terminal on August 2 (range 0-4).

Large areas of the hedge were completely defoliated by late June, and total defoliation had occurred by mid-July (Figs. 4-5). Only a few greenish stems and seed clusters remained to contrast with the brown stems. Many adults still clung to the bare stems, but some had dispersed to nearby ornamentals, and a few had notched leaves on understory goldenrods, *Solidago* spp. As soon as refoliation took place, the adults stripped the new growth. There was no evidence of a second generation on the defoliated hedge, although at this same time in 1977 and 1978, eggs and early instar larvae of a second brood were found on native ninebark.

The bare branches of the hedge were cut to nearly ground level in late winter 1978 by the Department of Transportation. Since no overwintering beetles were taken in duff samples from beneath the planting and no regrowth was evident by early May when native ninebark had fully leafed out, we discontinued our observations. In early July, however, Transportation officials informed us that some regrowth, ca. 10-15 cm high, had appeared at the base of the dead stems. Adults of the first generation and eggs of an apparent second generation of *C. spiraeae* were present along with late instar larvae of the first generation. The population, although much reduced compared to 1977, kept growth at a minimum so that by September only a few scattered stems bearing small leaves were evident.

Duration of immature stages. In the laboratory at 20-22°C incubation time for eggs of *C. spiraeae* averaged 5 days, and larval development was completed in an average of 18.9 days (Table 1). Each of the first 3 larval stadia lasted slightly more than 3 days, with the fourth requiring an average of 9.4 days. The fourth-instar larva fed for about 3 days on leaves of its host, then entered the soil and pupated just beneath the surface within 4-9 days.

Natural enemies. Eggs, late instar nymphs, and adults of the pentatomid *Podisus maculiventris* (Say), the spined soldier bug, were found on the ornamental planting of ninebark in late June 1977. Only a few first generation larvae of *C. spiraeae* remained on the plants, but the once large population must have attracted this predaceous hemipteran. A *Podisus* adult quickly attacked a teneral adult of the chrysomelid when the 2 were placed together in the laboratory.

Table 1. Duration (to nearest whole number of days) of eggs and larval and pupal stadia of *C. spiraeae* reared at 20-22°C.

Stage	No. Individuals	Range	Mean	Cumulative mean age
Egg	2	5	5.0	5.0
Larval Stadia				
1st	10	3-4	3.2	8.2
2nd	10	3-4	3.2	11.4
3rd	10	3-4	3.1	14.5
4th	8	7-12	9.4	23.9
Pupa	8	7-11	8.2	32.1

Two second generation eggs of *C. spiraeae,* parasitized by the pteromalid wasp *Erixestus winnemana* Crawford, were collected from ornamental ninebark on June 29, 1977. These eggs produced 2 wasps on July 7, 1977. On May 10, 1978, a female of *E. winnemana* was found searching over a cluster of 10 *C. spiraeae* eggs on native ninebark. When the eggs were brought into the laboratory, the first wasp emerged on May 20, 8 additional wasps emerged during May 21-22, and a tenth specimen on May 24. Another parasitized egg cluster was collected on May 30. This parasitoid was originally described as parasitic on eggs of *C. bigsbyana* (Kirby)[2] and *C. scalaris* (Crawford 1910) and was reared from eggs of *C. spiraeae* by Mullins (1976).

Description of the Egg
(Figures 6-7)

Measurements. Ovoid, elongate; approximately 1.8-1.9 mm long, 0.8 mm wide. Color varies from bright to dark orange-yellow. Egg shell surface bearing a network of minute, round, dome-shaped, nearly contiguous granules (Fig. 6). An SEM photo (Fig. 7) illustrates this chorionic configuration.

Specimens examined. Five eggs, collected from native ninebark, *Physocarpus opulifolius,* along Rte. 443, Middle Paxton Twp., Dauphin Co., Pennsylvania, mid-May, 1978. A. G. Wheeler, Jr., collector. Determined by association with reared adults.

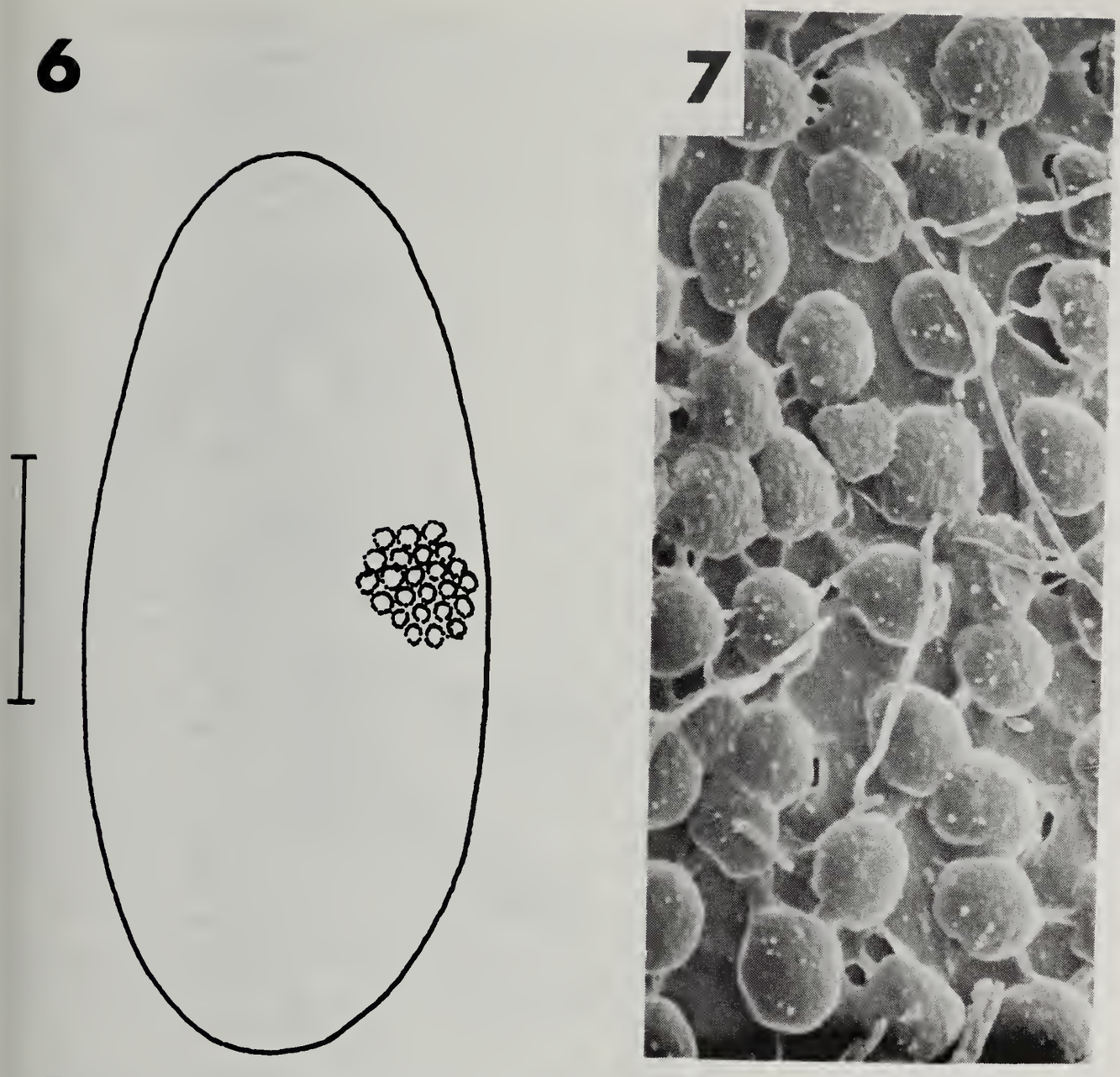
The SEM photomicrograph was taken with an AMR-1000A Scanning Electron Microscope on Polaroid Type-55 film; the subject was coated with a 160-200 angstroms gold film in a Balzers Sputter Coater at Cornell University, Ithaca, New York, with the assistance of Mr. Richard L. Brown.

Description of the Fourth-Instar Larva
(Figures 8-13)

Measurements. Length 8.0-9.0 mm. Color pale yellow or cream-colored; integument bearing indistinct, minute pavement granules and simple setae. Body subcylindrical, cyphosomatic, slightly tapered posterad (Fig. 9). Head capsule largely brown, with darker "freckles," usually with broad anterior area and broad lateral area behind ocellar region pale.

Head. Large, exserted, hypognathous, rounded, hind dorsal margin evenly convex; distinct coronal suture present; frontal sutures present, V-shaped, extending nearly to antennal bases. Antennae (Figs. 9 & 12) located laterad, at distal ends of frontal sutures; 3-segmented; basal segment short, ring-shaped; segment 2 twice as long as segment 1; segment 3 conical, slightly acicular; segment 2 with small apical papilla, half as long as segment 3; segments 1-3 dark brown to piceous. Six (6) ocelli present on each side of head capsule, above, posterad and below each antennal base (Fig. 9); a group of 4 ocelli above and posterad and a group of 2 posterad and below each antennal base. Distinct frontal-clypeal suture present; clypeus nearly 4 times as wide as long with 3 long, erect setae on each side of midline in oblique row (Fig. 8); upper margin broadly pigmented light to dark brown. Labrum light to dark brown, nearly 2 times as wide as long, acutely emarginate at apex in middle; 2 long, erect setae on each side of midline. Epipharynx simple with 3 short, stout, flattened setae on each side at apex. Mandibles (Fig. 10) stout, with 5 rounded teeth apically; 2 setae present on dorsal outer surface. Maxillary palpi 3-segmented (Fig. 13), piceous; palpifer with 2 setae on ventral surface; basal segment short, ring-shaped; segment 2

[2]*C. bigsbyana* (Kirby) now equals *C. multipunctata* (Say) (Wilcox 1975).



Figs. 6-7. Egg of *Calligrapha spiraeae*. 6) Habitus (lateral view) showing portion of sculpturing of egg chorion. 7) SEM photo of egg chorion, 530X (debris present on egg surface). [scale line = 0.5 mm for Fig. 6].

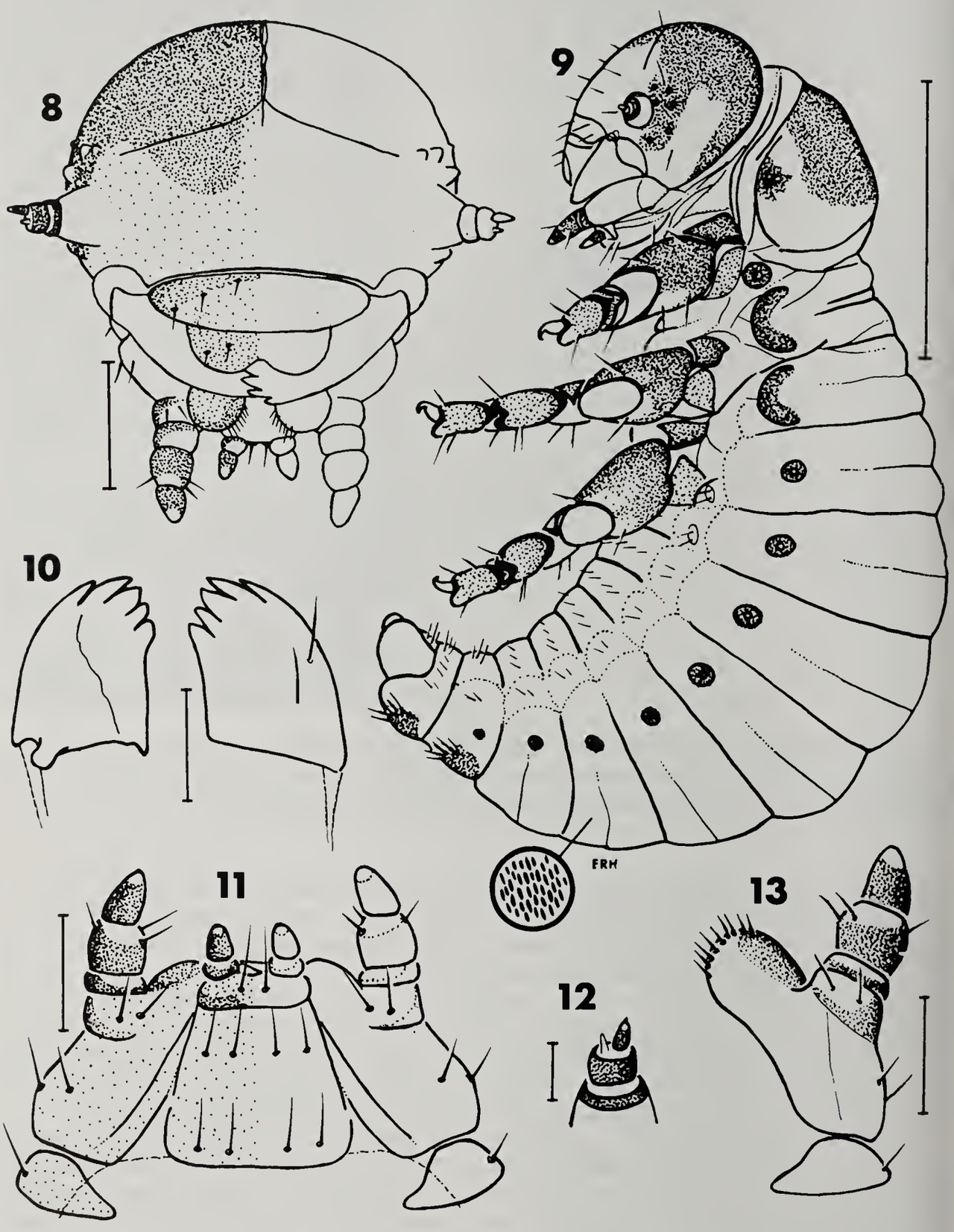
longer than basal segment, widest at middle, with 2 setae on inner ventral surface and 1 seta on outer dorso-lateral surface; apical segment as long as segment 2, narrower, tapered at apex; inner and apical margin of maxillary mala (Fig. 13) beset with several stout, erect setae; cardo broadly triangular with 1 seta on outer ventral surface; stipes large, fused, with 2 setae on outer surface below palpus. Prementum of labium (Fig. 11) broadly transverse, lightly pigmented, with 2 setae in middle of disk. Labial palpi 2-segmented, piceous; basal segment shorter than apical segment; apical segment tapered to apex. Postmentum (=combined mentum and submentum) nearly as broad as long with 4 pairs of setae, 2 pair on each side of midline.

Thorax. Pronotal shield largely brown, lightly sclerotized, slightly longer than dorsal length of meso- and metathorax combined. Legs (Fig. 9) comparatively large; coxae large; tibiae slightly shorter than femora; claw simple, curved, tapered to apex; prothoracic spiracle moderate in size, annular, surrounded by circular, brown area; dark brown transversely lunate spots on lateral aspects of meso- and metathorax.

Abdomen. Ten-segmented with venter of tenth segment proleg-like. Mid-abdominal segments with greater diameter than cephalic or caudal segments. Spiracles on lateral aspects of segments 1-8, annular, bordered by brown-piceous rings. Eighth

and ninth tergites each with large, transverse, brown area; margined apically with row of setae. Venter of all segments beset with transverse row of setae.

Specimens examined. Numerous larvae collected from ornamental and native ninebark, *Physocarpus opulifolius,* at I-81 rest area, nr. Grantville, Dauphin Co., Pennsylvania, 28-29 June, 1977, and along Rte. 443, Middle Paxton Twp., Dauphin Co., Pennsylvania, 8-23 August, 1977. A. G. Wheeler, Jr., collector. Determined by association with reared adults.



Figs. 8-13. Larva of *Calligrapha spiraeae.* 8) Frontal aspect of head. 9) Habitus (lateral view). 10) Right mandible, ventral (left) and dorsal (right). 11) Maxilla and labium (ventral view). 12) Antenna. 13) Left maxilla and palpus (ventral view). [Scale line = 0.45 mm for Fig. 8; 3.0 mm for Fig. 9; 0.42 mm for Fig. 10; 0.3 mm for Figs. 11 and 13; and 0.1 mm for Fig. 12].

Description of the Pupa
(Figures 14-16)

Measurements. Length 9 mm. Shape elongate, robust, exarate. Color pinkish-white.

Head. Transverse, widest across eyes, tapered towards vertex in frontal-dorsal aspect, with stout setae above antennal bases and eyes (Fig. 15). Mouthparts directed posteriorly. Eyes, antennae, mandibles, and palpi clearly discernible.

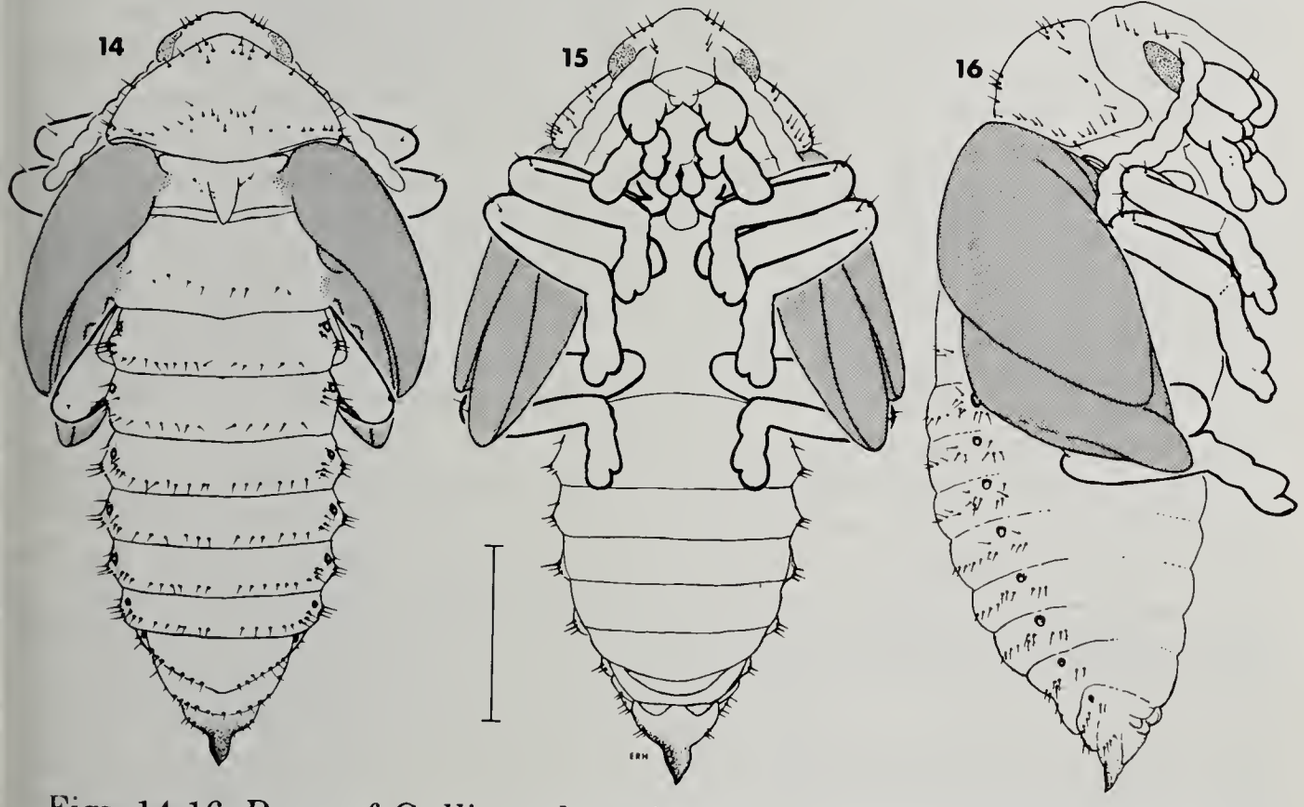
Thorax. Pronotum subtriangular, transverse, widest at base, with irregularly placed setae along lateral, anterior, and sub-basal margins (Figs. 14-16). Mesonotum with minute setae around base of scutellum (Fig. 14). Scutellum large, elongate, triangular. Metanotum (Fig. 14) bearing short setae along irregular transverse row on basal half. Elytra closely appressed and curving around body, extending posteriorly to abdominal segment 2. Fore-, meso-, and metafemora subperpendicular to longitudinal axis of body; all legs bearing short setae at femoral-tibial articulation.

Abdomen. Nine movable segments; segments 1-6 (Fig. 14) dorsally bearing transverse row of short setae on apical margin. Cluster of 3 short setae arising posterad of spiracles on segments 1-6 (Fig. 16). Spiracles of segments 1-8 situated laterally, darkly pigmented, annular; spiracles of segment 8 small. Segment 7 (Fig. 14) broadly triangular dorsally, tapered to apex; apical margin bearing setae except at apex. Segment 8 broadly rounded dorsally at apex with apical row of setae. Segment 9 broadly transverse basally, strongly constricted at middle, tapered to point at apex; darkly pigmented (Figs. 14-16). Abdominal venter devoid of setae. Pair of fleshy swellings ventrally at base of segment 9 (Fig. 15).

Specimens examined. One pupa reared from larva collected from native ninebark, *Physocarpus opulifolius*, along Rte. 443, Middle Paxton Twp., Dauphin Co., Pennsylvania, 8 June, 1978. A. G. Wheeler, Jr., collector. Determined by association with reared adults.

With the description of the mature larva of *C. spiraeae,* Brown's (1945) key to five species of *Calligrapha* larvae is here revised to include *spiraeae.* Brown's couplet #1. (p. 121) is modified to read as follows:

1. "Head capsule largely brown, with anterior and lateral areas and a



Figs. 14-16. Pupa of *Calligrapha spiraeae.* 14) Dorsal aspect. 15) Ventral aspect. 16) Lateral aspect. [scale line = 2.0 mm].

very narrow median line pale. Labrum and palpi largely brown. Pronotal shield largely brown, the anterior and basal margins narrowly and the median line very narrowly pale, the broadly pale lateral margins enclosing a large brown spot on each side. The transversely lunate, brown spot on each side of the meso- and of the metathorax heavier than in the other species. Coxae and the sclerites to which they are attached basally, entirely brown on the outer side. Eighth and ninth abdominal tergites each with a large, transverse, brown area. Body smaller. (10 larvae taken from the food plant at Simcoe and Delhi, Ont.) ..... 23. *pruni* n. sp."

Head capsule largely dark brown, with darker mottling, usually with broad anterior area and broad lateral area behind ocellar region pale. Labrum light brown, palpi dark-brown to piceous. Pronotal shield largely brown, the basal margin narrowly and the median line very narrowly pale, the broadly pale lateral margin enclosing a large brown spot on each side. A large transversely lunate brown spot on each side of the meso- and metathorax. Coxae, and the sclerites to which they are attached basally, brown. Femur and tibia pale to light brown on outer surface, pale on inner surface. Basal and apical margins of femora and tibiae narrowly piceous. Eighth and ninth abdominal tergites each with a transverse brown area. (Numerous larvae taken from a native and ornamental planting of the food plant, ninebark, *Physocarpus opulifolius,* in Dauphin Co., Pennsylvania) ..... *spiraeae* (Say).

"Head capsule entirely pale except in the ocellar areas. // ..... "2.

Discussion

Our biological data derived from populations of *C. spiraeae* on native and ornamental ninebark in Pennsylvania differ in several respects from the observations made on this species in Virginia (Mullins 1976). Of primary importance is the observation that this chrysomelid is bivoltine, having produced a small second brood in both years of study. Brown (1945) stated that all *Calligrapha* species known from Canada are univoltine, and to our knowledge this is the first record of a second generation occurring in the genus. It seems likely that the "new adults" reported by Mullins to emerge in late August represented a second rather than a first generation.

Mullins (1976) characterized the last larval stage as non-feeding. In our study, however, fourth-instar larvae fed for several days in the field and laboratory before entering the soil to pupate.

The observation of defoliation to an ornamental hedge of ninebark marks the first record of *C. spiraeae* as an economically important insect. In both years populations were small on native ninebark. Large populations capable of damaging their hosts probably develop only rarely on ninebark growing along water courses and in thickets. The concentration of the host plant as an ornamental in an open area produced an artificial environment possibly conducive to the build-up of a large beetle population. *C. spiraeae* thus may be another example of an insect maintaining nondestructive levels in a natural environment but reaching outbreak proportions under altered conditions.

Acknowledgments

We are grateful to J. F. Stimmel, Pa. Dept. Agric., for taking the photographs and preparing a rough draft of Fig. 1 and H. H. Lyon, Cornell Univ., for reproducing the photographs. L. L. Pechuman, Cornell Univ., K. Valley, Pa. Dept. Agric., and R. E. White, Systematic Entomology Laboratory, U.S. Dept. Agric., kindly reviewed the manuscript and offered suggestions for its improvement. We express our appreciation to E. C. Becker, Biosystematics Research Institute, Agriculture Canada, for providing locality data of specimens in the Canadian National Collection. Finally, we thank M. E. Carter for typing the manuscript.

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